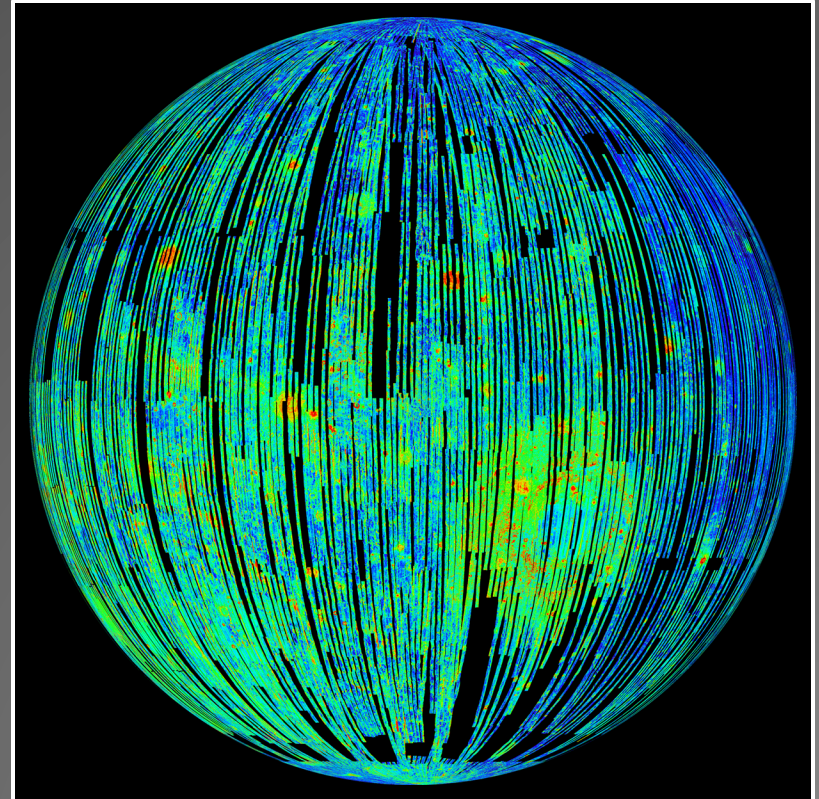
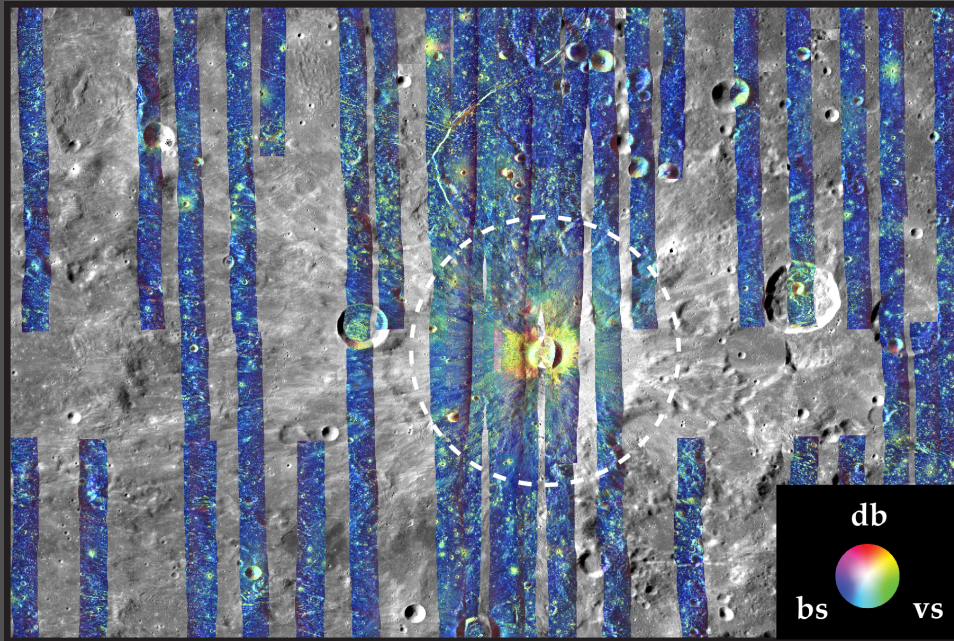


The m-chi decomposition of hybrid dual-polarimetric radar data with application to lunar craters



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Ben Bussey, and the Mini-RF Team

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INTRODUCTION: MINI-RF

- Hybrid dual-polarized SAR
 - Transmits S-band (12.6 cm) and X-band (4.2 cm) wavelengths and can operate in two modes: a baseline mode with a resolution of 150 m and a zoom mode with a resolution of 30 m.
 - Measures returned signals in two orthogonal polarizations; allow for the calculation of the four Stokes parameters $[S_1, S_2, S_3, S_4]$.



BACKGROUND: DATA PRODUCTS

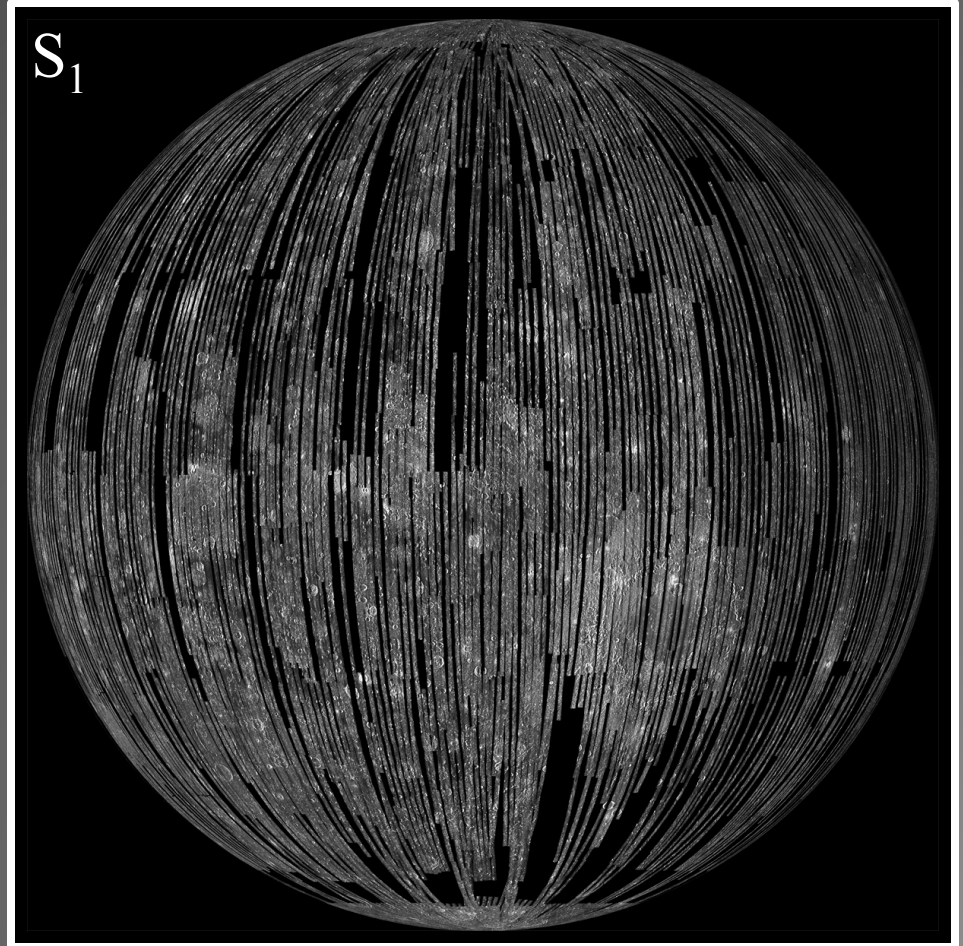
Stokes Parameters

$$S_1 = \langle |E_H|^2 + |E_V|^2 \rangle$$

$$S_2 = \langle |E_H|^2 - |E_V|^2 \rangle$$

$$S_3 = 2 \operatorname{Re} \langle E_H E_V^* \rangle$$

$$S_4 = -2 \operatorname{Im} \langle E_H E_V^* \rangle$$

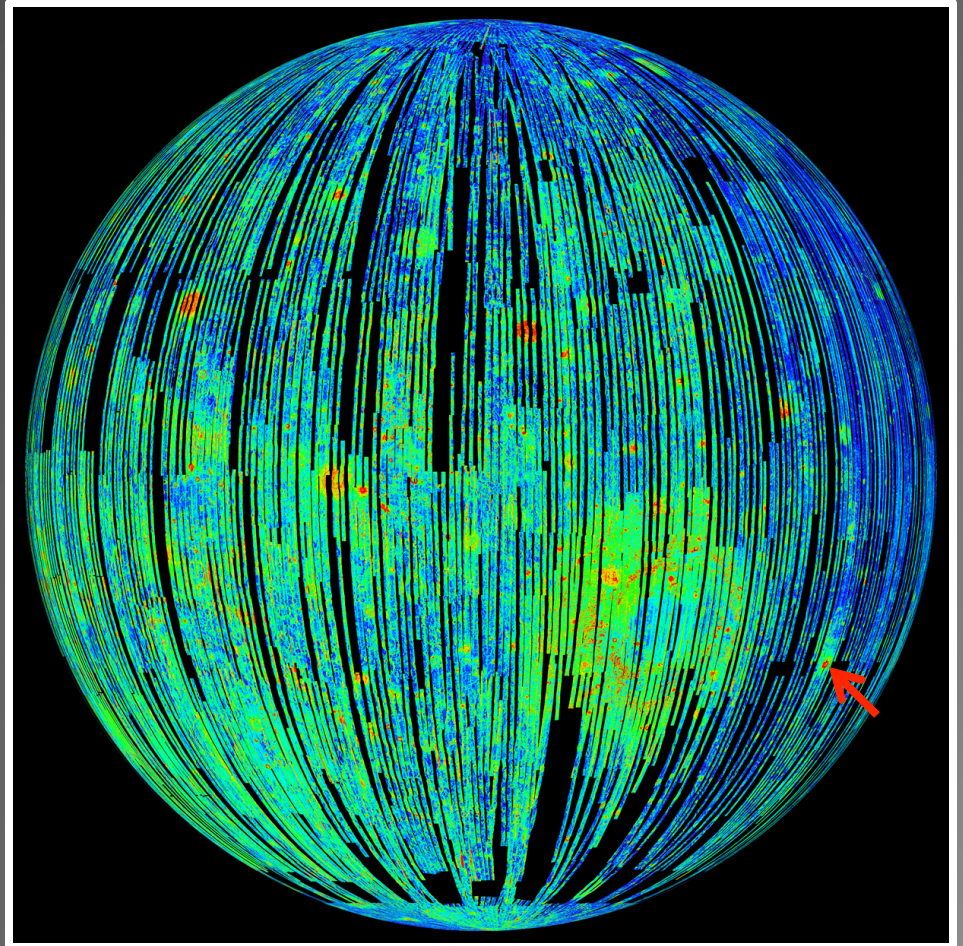


BACKGROUND: DATA PRODUCTS

Circular Polarization Ratio (CPR)

$$\text{CPR} = (S_1 - S_4) / (S_1 + S_4)$$

- Indicator of the roughness of a surface, as determined by the distribution of radar scatterers at the wavelength scale and larger (*e.g.*, boulders).
- Young, fresh craters are distinctive in radar images obtained with the Mini-RF instrument because of the surface roughness associated with their ejecta deposits.



BACKGROUND: DATA PRODUCTS

Decomposition by m-chi (*Raney et al., 2012*)

$$R = [S_1 m (1 + \sin 2\chi)/2]^{1/2}$$

double bounce backscatter
(*dihedral, volume ice*)

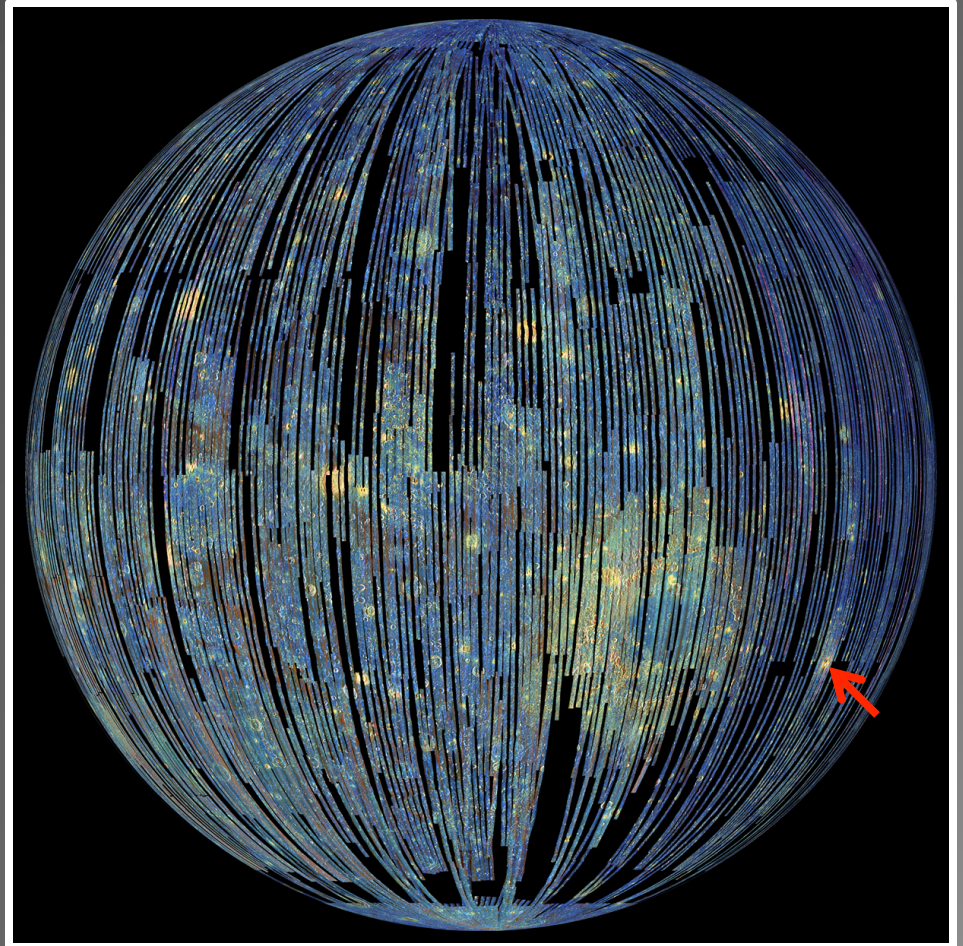
$$G = [S_1 (1 - m)]^{1/2}$$

randomly polarized
(*volume scattering*)

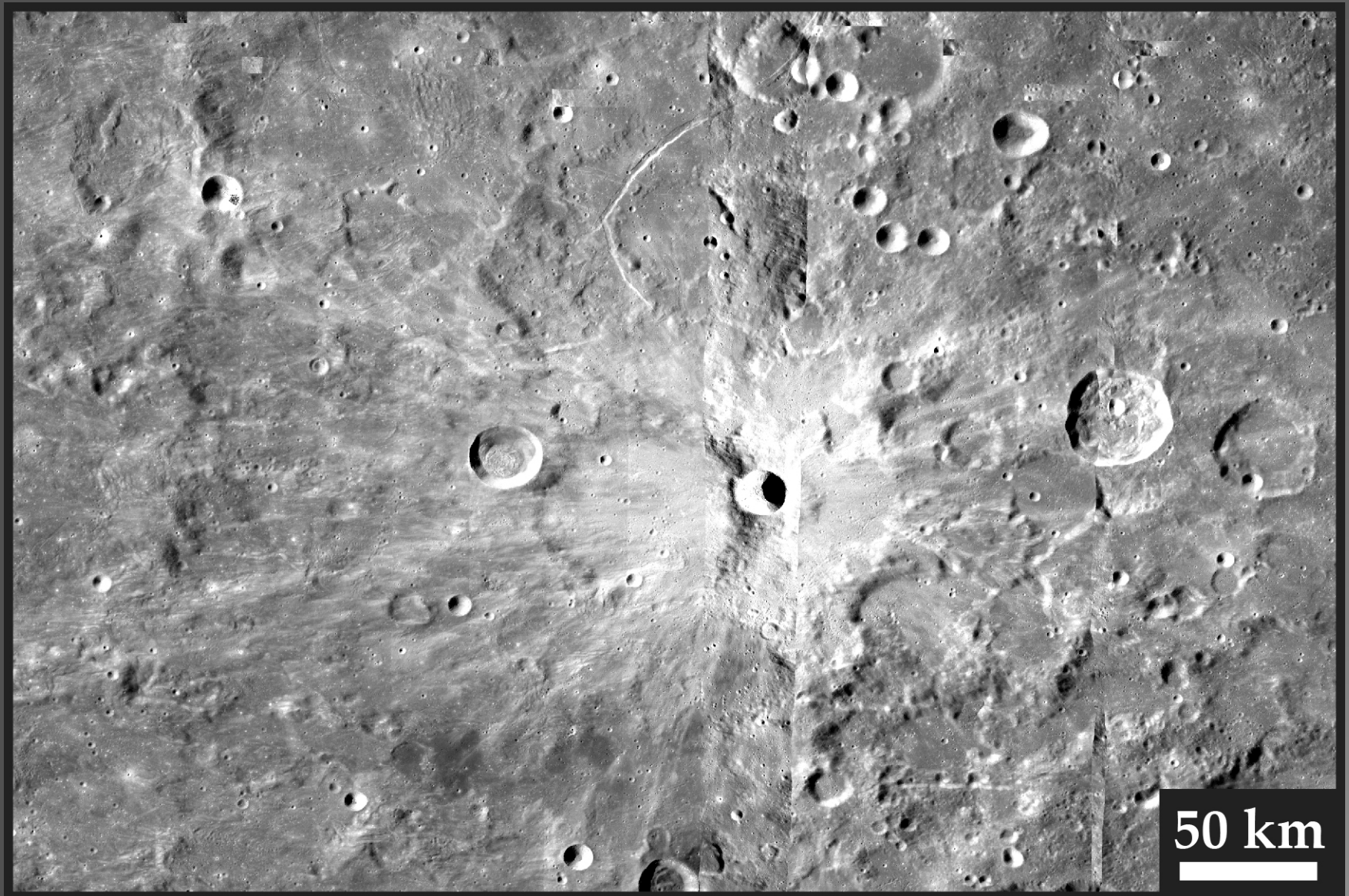
$$B = [S_1 m (1 - \sin 2\chi)/2]^{1/2}$$

single bounce backscatter
(*Bragg scattering*)

$$S_1 = R^2 + G^2 + B^2$$



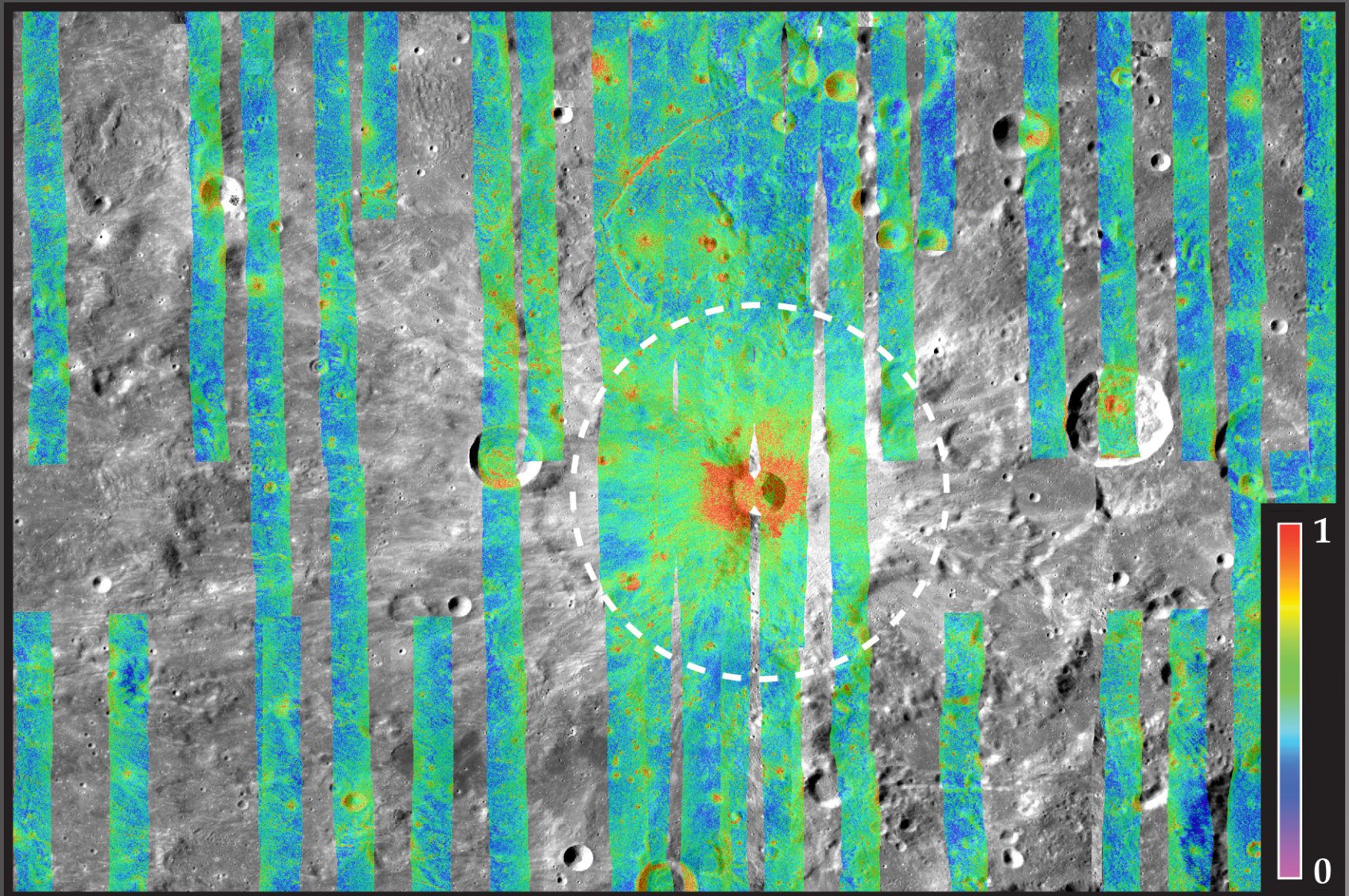
OBSERVATIONS: BYRGIUS A



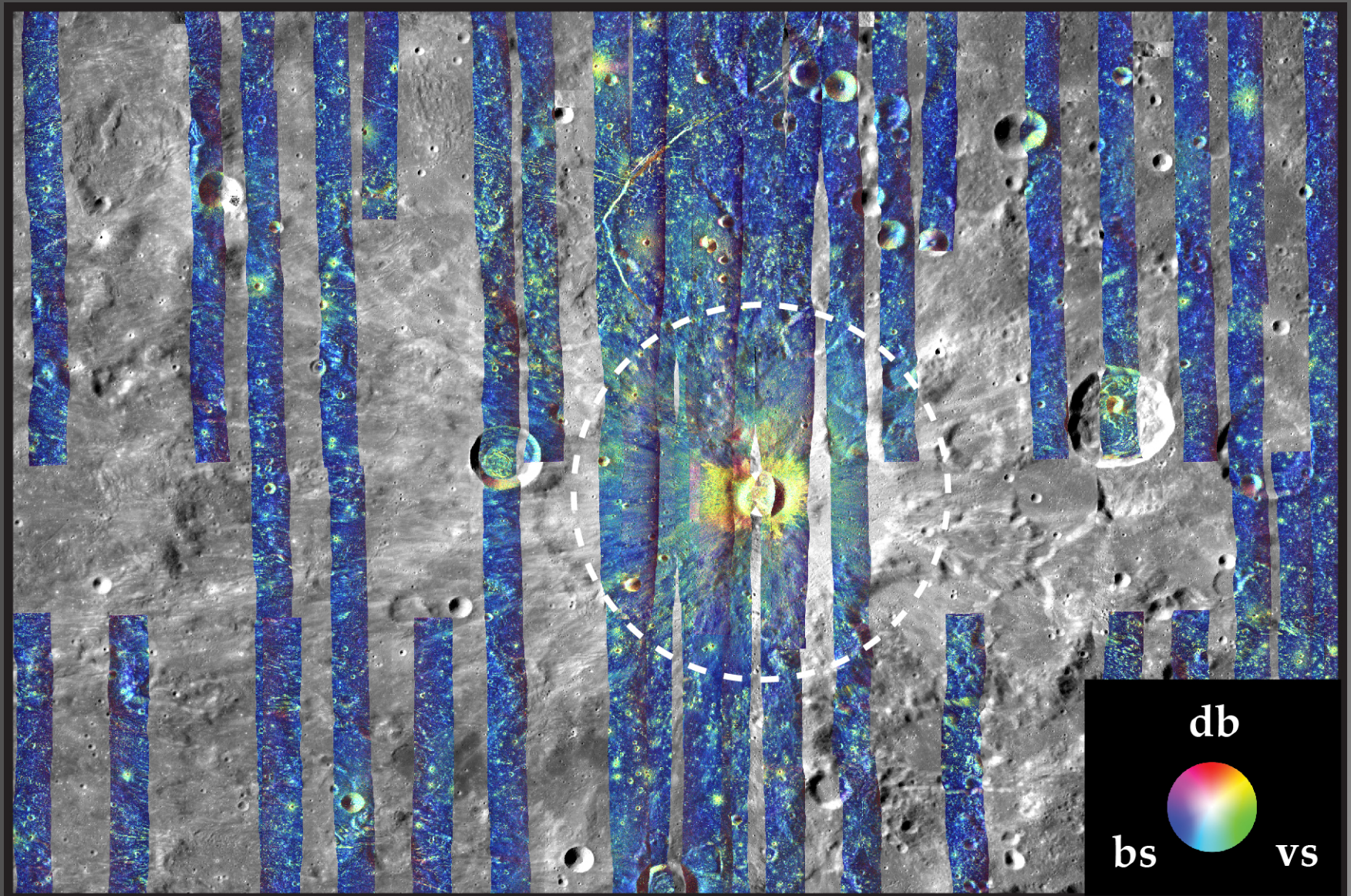
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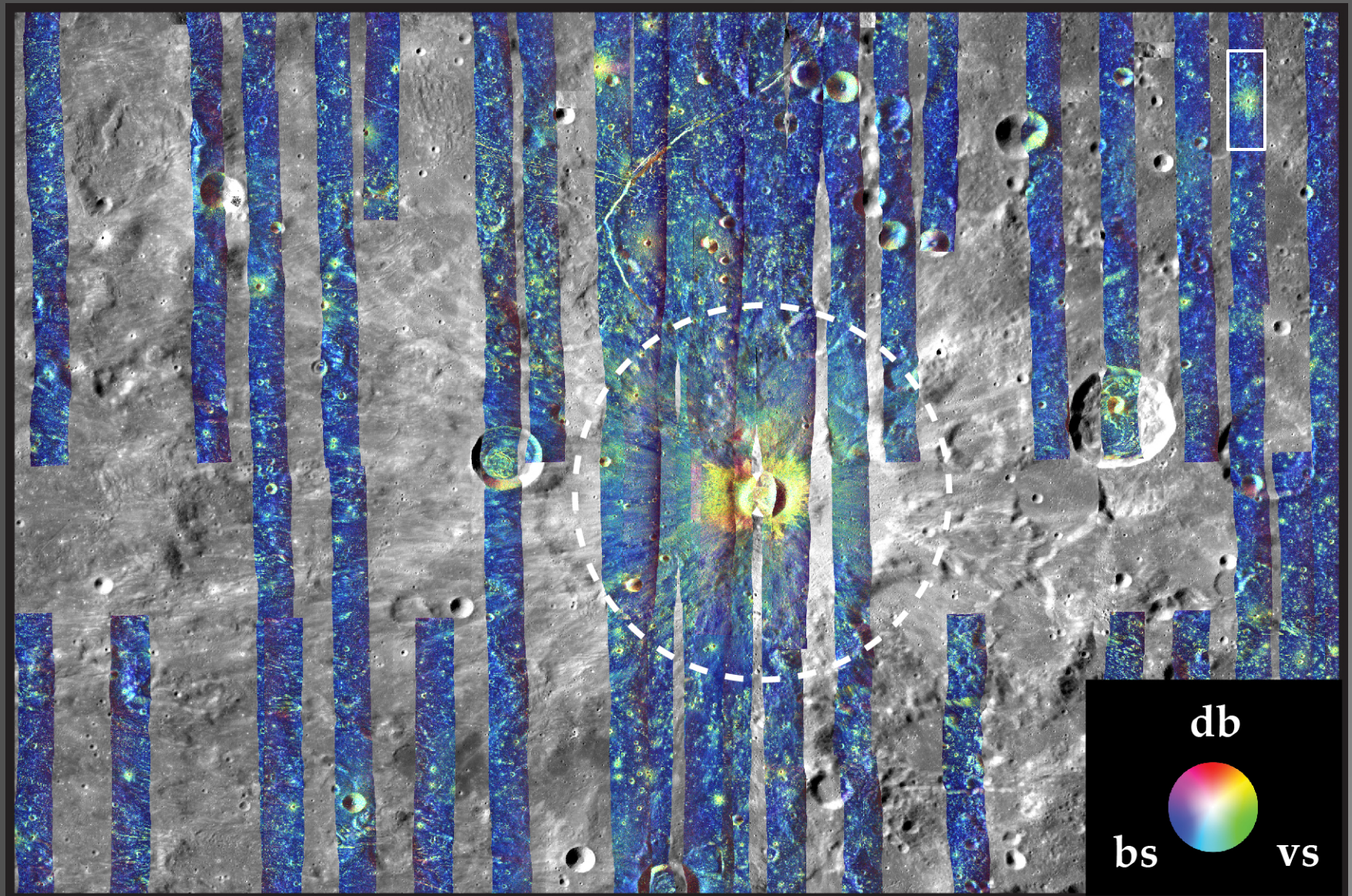
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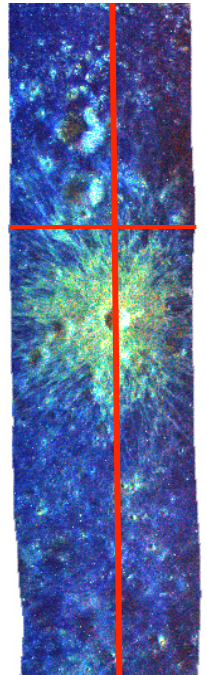
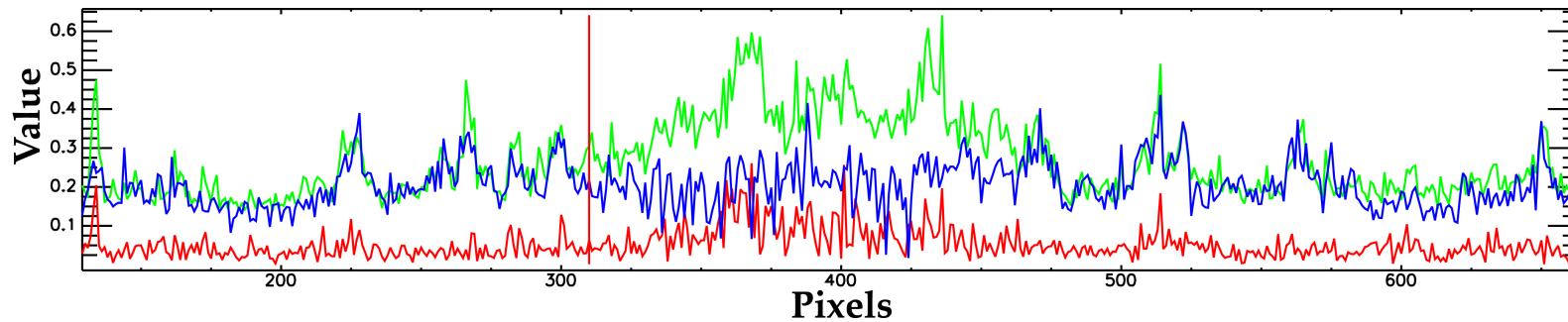
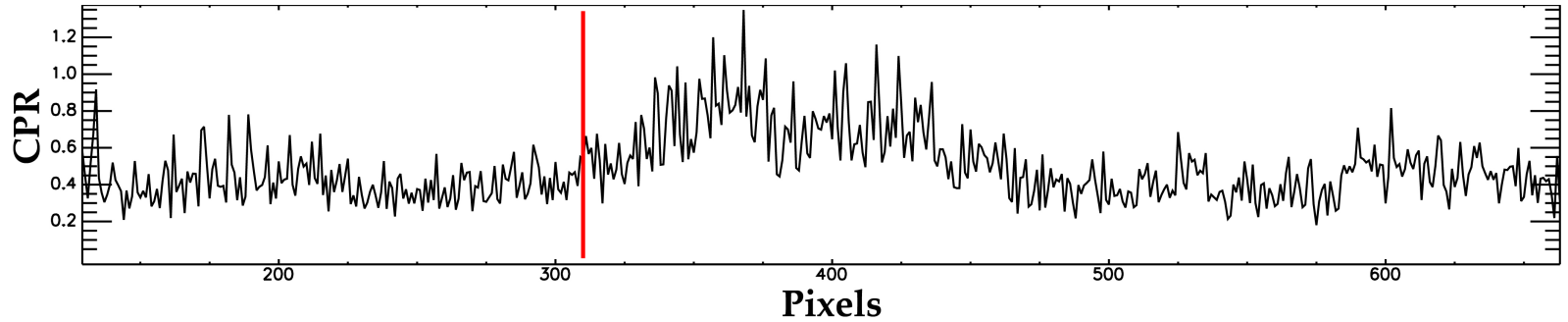
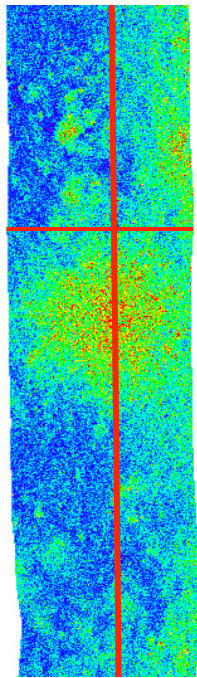
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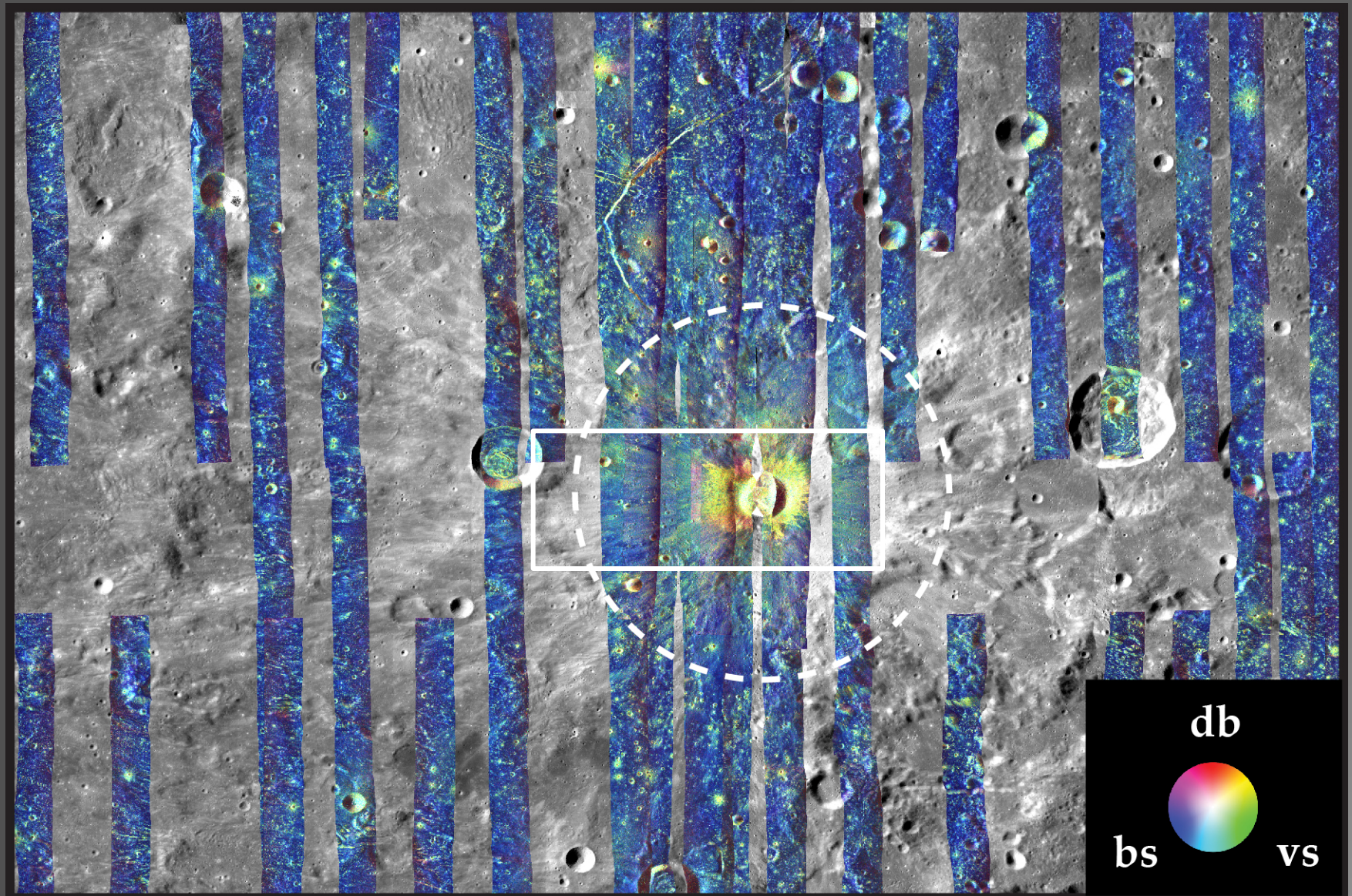
ANALYSIS: BYRGIUS A



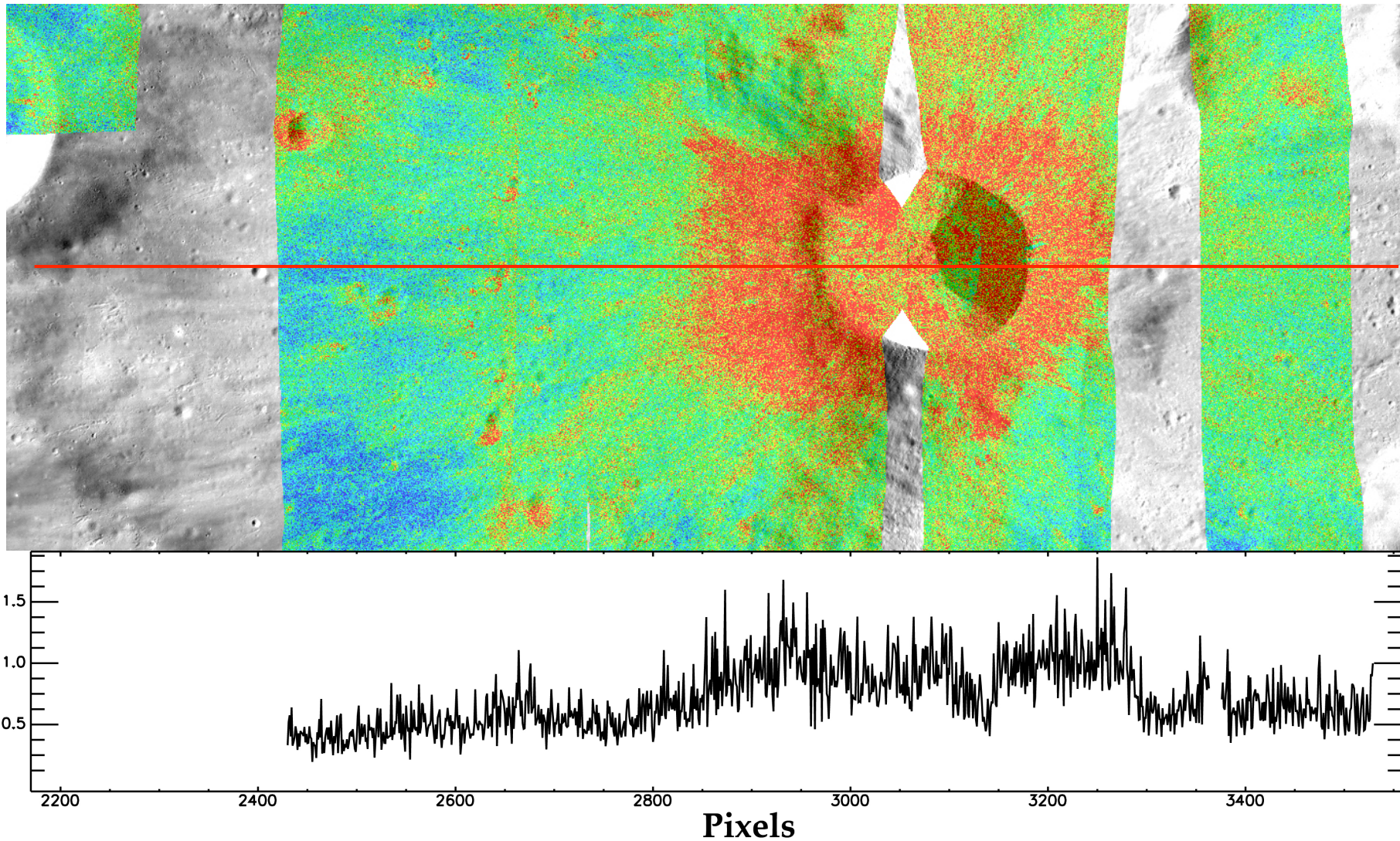
ANALYSIS: BYRGIUS A



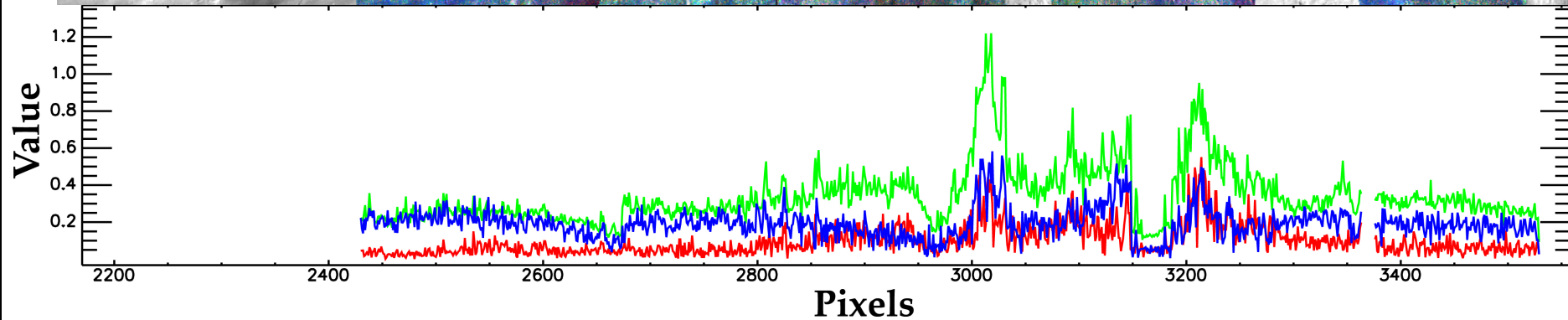
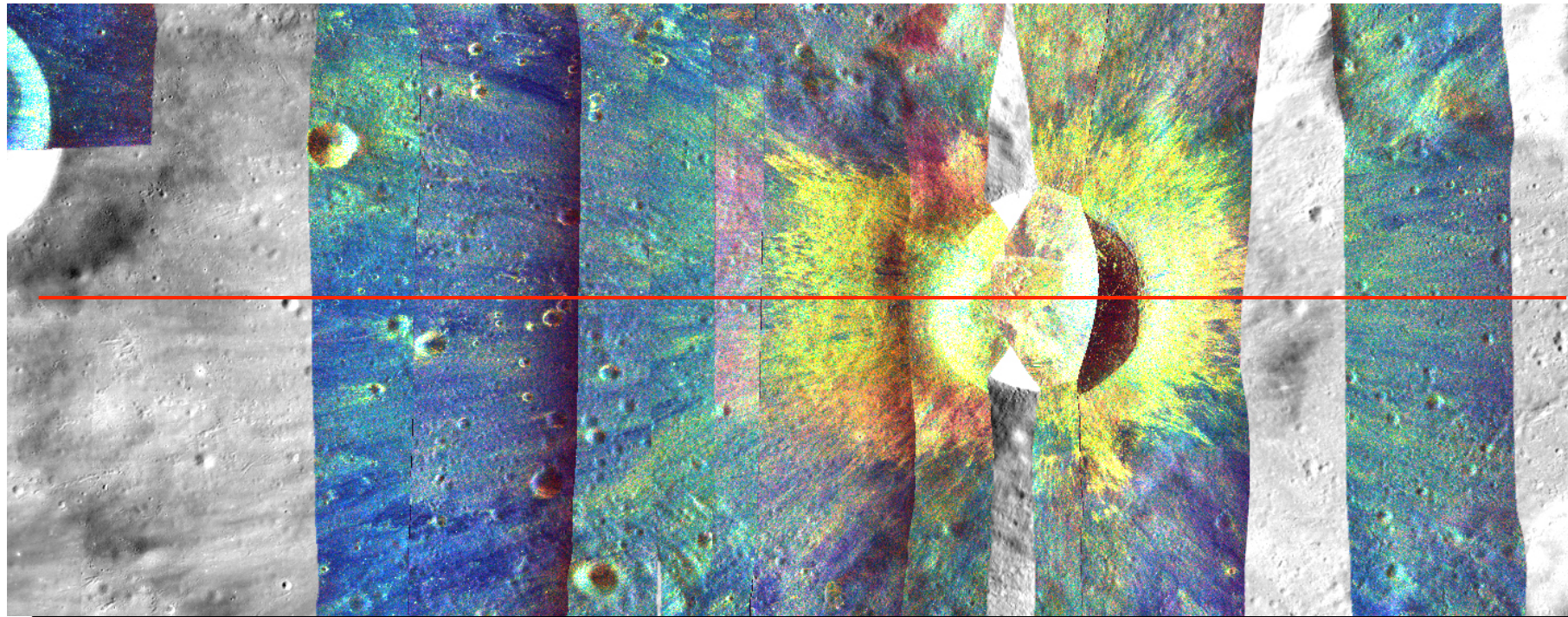
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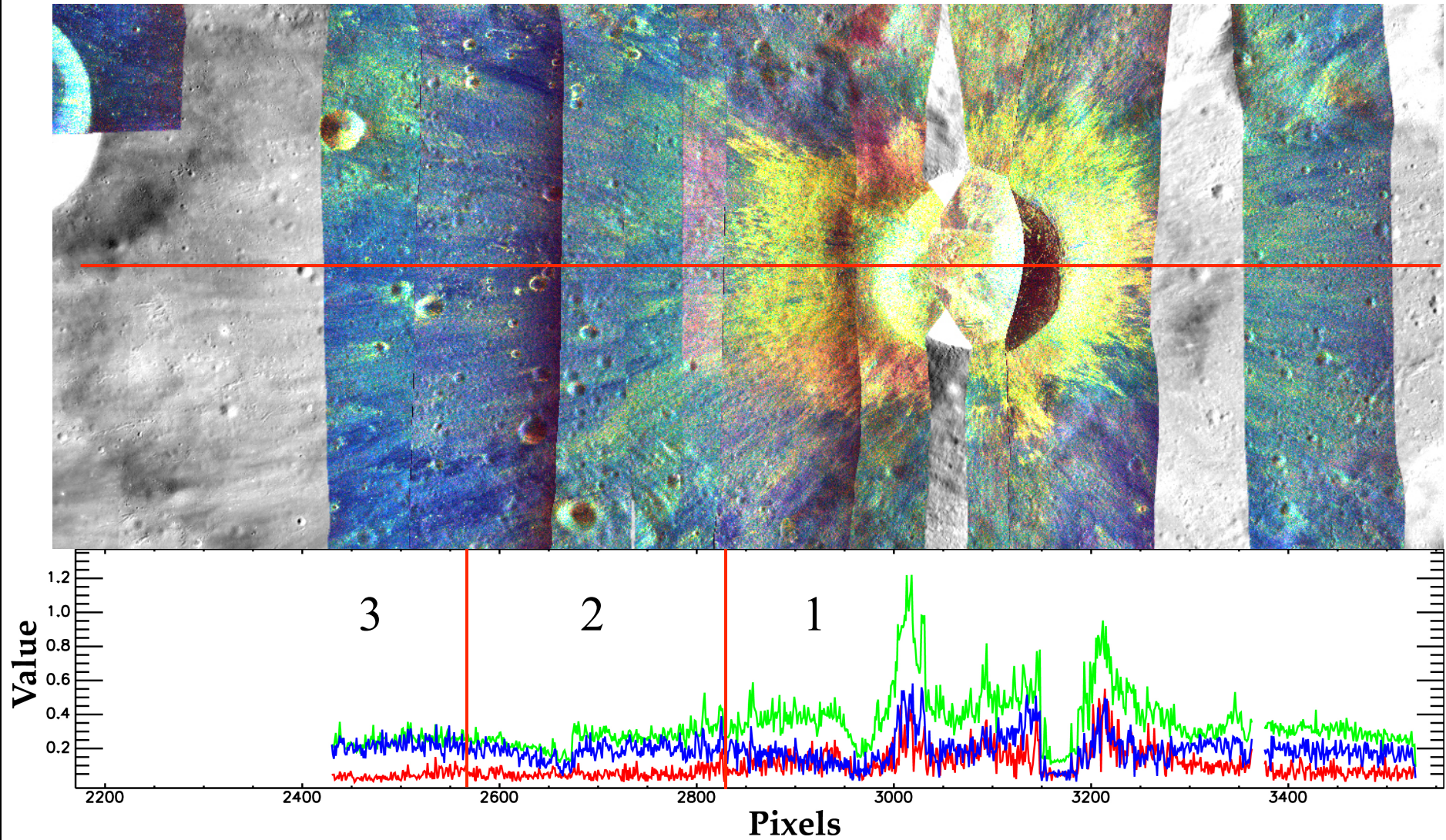
ANALYSIS: BYRGIUS A



ANALYSIS: BYRGIUS A

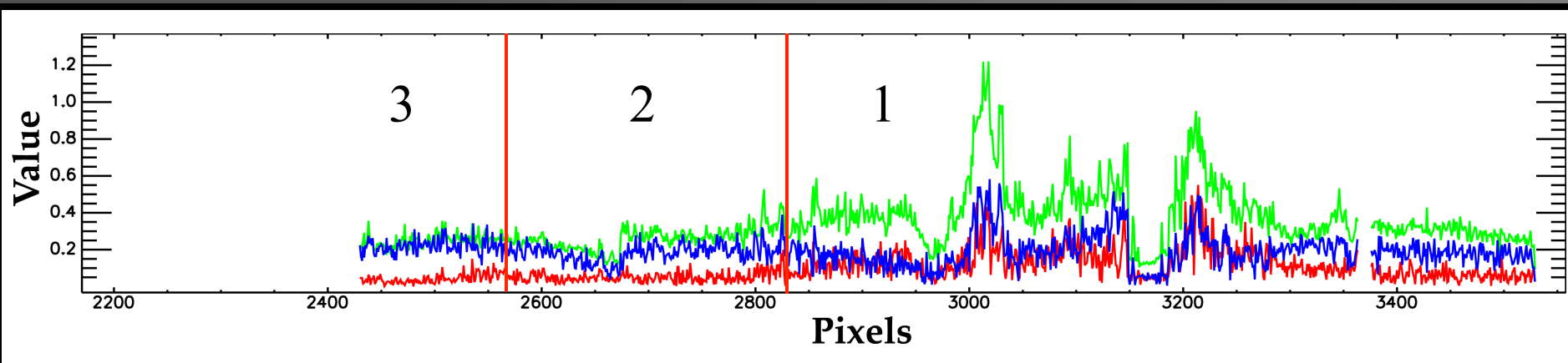


ANALYSIS: BYRGIUS A



WORKING HYPOTHESIS

1. Scattering signature of crater ejecta
2. Scattering properties of crater ejecta and lunar regolith are observed
 - Thickness of ejecta is less than penetration depth of radar signal
3. Scattering signature of lunar regolith



CONCLUSION

The thickness of ejecta for Byrgius A at radial distances > 10 km from the crater rim is on the order of meters

- McGetchin et al. (1973) predict ejecta thickness of ~15 m at this distance
- Pike et al. (1974) predict ejecta thicknesses in the range from 36 to 91 m

FUTURE WORK

We have identified 22 additional fresh, young craters in highland and mare materials that were observed by the Mini-RF instrument during its nominal mission.

Crater	Diameter (km)	Lat.	Lon.
Furnerius A	12	-33.50	59.00
Dugan J	13	61.60	108.00
Klute W	13	38.20	-143.00
Byrgius A	19	-24.50	-63.70
Dufay B	20	8.50	171.00
Giordano Bruno	22	35.90	102.80
Proclus	28	16.10	46.80
Birkhoff Z	30	61.30	-145.30
Necho	30	-5.00	123.10
Schomberger A	31	-78.80	24.40
Thales	31	61.80	50.30
Guthnick	36	-47.70	-93.90
Bel'kovich K	47	63.80	93.60
Anaxagoras	50	73.40	-10.10

Crater	Diameter (km)	Lat.	Lon.
Harpalus E	7	52.70	-50.80
Louville D	7	46.90	-52.10
Bessarion	10	14.90	-37.30
Gambart A	12	1.00	-18.70
Dionysius	18	2.80	17.30
Kepler	31	8.10	-38.00
Petavius B	33	-19.90	57.10
Harpalus	39	52.60	-43.40
Aristillus	55	33.90	1.20